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Supporting the Development of Digital Skills

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Abstract. In a world where activities, goals and available software are rapidly changing, users must constantly adapt. In this position paper, we discuss how digital skills are different from traditional skills due to their highly dynamic nature, both in the tools used and the tasks to be carried out. We advocate the needs both for interdisciplinary theory to conceptualize digital skill development, and for longitudinal, large-scale and trace-based methods to observe such phenomenon. We illustrate how digital tools could better support users in the development of skills, highlighting how traces of interaction could be leveraged within reflective and skill-sharing tools.

1 Introduction

Over the last few decades, knowledge work, i.e. gathering, processing and transforming information, has become a predominant activity within society. Pioneers such as Bush or Engelbart clearly envisioned computers as a medium to support knowledge work through dedicated information management tools. They also acknowledged that this new form of knowledge work would involve particular expertise, and require the development of digital skills. This need is accentuated by the constant and rapid evolution of digital tools. This makes it challenging for users to form durable and stabilized practices, leading them to constantly re-develop their skills to cope with their ever-changing digital environment.

Existing applications offer very little means to cope with these changes and support users in the development of their digital skills, i.e. in the permanent evolution of the way they make best use of software. In their attempts to master digital tools, users waste precious time exploring software features through trial and error, or rely on even more time consuming training or tutorials. We argue that a better understanding of digital skill development could lead to a new generation of reflective and skill-sharing tools. Such tools would enable end-users to develop digital skills in a seamless fashion as they conduct their activities, but also let them reflect upon and share these skills. This project opens perspectives in software design to better support appropriation by users, to foster skill development, to limit stress and loss of productivity related to new technology deployment and more generally to contribute to citizens' digital literacy.

2 Developing digital skills

A skill can be generally defined as the learned ability to perform actions with ease and mastery, without requiring much conscious effort. When related to a tool, a skill integrates the ability to manipulate and operate this tool, but also to mobilize it relevantly, along with other resources, to reach given goals. For instance, as a skilled Photoshop user, Marie uses the software seamlessly and does not need to focus on the various features of the application. She can therefore truly focus on the aesthetic of the photos she is working on. Users develop their skills progressively: as they use their tools repeatedly, their manipulation becomes more fluid (development of operational skills), their integration in the practice becomes smoother (articulation with other resources and workflows), and the class of situations where the tool is deemed relevant becomes clearer for the user (development of task-related skills) [9, 13]. This developmental process, well analysed for traditional tools, is challenged in digital environments. Digitization, which contributes to the increasing complexity of knowledge work, has worsened three problems:

- The *integration problem*: a user digital environment is characterized by a complex articulation of tools, data structures, parameter sets and routines. For a user, developing new skills requires to elaborate new routines and representations that fit this environment. In some case, it also requires to reconfigure this complex environment, by taking care of not breaking any functions that are already supported. Integrating a new skill to an existing digital environment constitute a complex and time-consuming activity for which users do not benefit from any support by the system [9].
- The *instability problem*: users have to deal with the rapid evolution of their digital tools. They need to keep their skills up to date to cope with the regular software updates and device evolutions, and therefore cannot establish durable skills [9,16].
- The *visibility problem*: digital skills are performed within the confinement of one's screen, largely isolated from others' perception [15]. This problem limits vicarious learning which play an essential role in skills development and sharing.

The digital revolution transforms the way expertise is acquired, shared and deepened. Overcoming the problems we have identified would allow digital workers to better appropriate their tools, and to establish more efficient and durable practices.

3 The need for theory and methods on digital skill development

The development of digital skills has been addressed in the field of Human Computer Interaction through the development of concepts and methods to improve the learnability of software. These methods are generally dedicated to the operational dimension of software handling (e.g. how to open a file) and prototypical use (e.g. how to make a photo montage). They are not rich enough to account for the situated needs and practices of users and address their high-level goals (e.g. how Marie can polish a document provided by a colleague, so it can be printed on the company printer).

Current approaches come with limited interdisciplinary theoretical grounding to encompass the various dimensions and the relatively long timespan related to skill development. The fact that Marie develops a skill related to image saturation in Photoshop involves a variety of factors: the affordances offered by the tool; Marie's exploration, simulations, and repeated confrontations with the relevant features; advices she got reading a blog article, talking to a friend, etc. As we see, understanding skill development requires the consideration of a variety of factors, and to account for insights from a range of disciplines that are traditionally separated: *developmental psychology* is necessary to understand how an individual learn and internalise knowledge [9]; *cognitive psychology* provides insights about the knowledge transformation involved in such a process [7]; *ergonomics* and *organizational science* emphasize the importance of technical and organizational factors [6]; *sociology* and *anthropology* help to understand how a skill is conditioned by signs and cultural constructs associated with the related practice [16]; etc.

All these disciplines take skill development into account in their own way, and remain to be articulated to overcome the limitations of prior work. A holistic framework is needed to articulate the various matters addressed by these disciplines (technical, psychological, cultural, etc.), to explain how these dimensions intertwine through different time-scales and add up to participate in the constitution of a skill by a user. Activity Theory [9], Instrumental Theory [13], or Heidegger's concept of Equipment as discussed by Riemer and Johnston [14] appear promising here, as they provide powerful concepts to explain the historical co-constitution of action, practice, individual development and culture. However these holistic theories remain difficult to use in their current state, as they stay too theoretical and abstract from IT designer's concerns, and as they are challenged by the peculiarity of digital practices [12, 14, 16].

Our theoretical approach to overcome these limitations consists in strengthening the notion of *mediation*, which is fundamental in all these works. We are developing a model of *digital mediation*, which account for the specifics of computer-mediated work (increased mediational indirectness, complex chain of mediation, etc. see [4]), and allow understanding phenomenon of mediation as they concretely occur in discrete digital environments. With this model, we aim at describing digital skills development as the establishment of complex forms of digital mediation, which can be both understood from both the perspective of the holistic theories we have mentioned, and the HCI and IT models that focus on the technical materialization of mediations.

Current approaches also lack *methods to observe skill development*, as such development occurs in real settings. As we mentioned, current work on the topic remains limited to *operational level* or *prototypal use cases*. These limitations are usually overcome by interviewing users and setting up ethnographic observations, but such methods remain costly and only allow small populations to be observed. As acknowledged in the Human Computer Interaction field [1,10,12,16], there is a need for novel methods that allow observations on both a *longitudinal basis* — to assess skill development as it unfolds over time and evolves in the long term; and on a *large-scale basis* — to account for the high variability between users.

We are tackling these issues with a trace-based approach [5], i.e. by capturing and processing interaction events between users and their computers in order to establish a

trace of their activity. We are currently developing data mining and visualization techniques to identify activity patterns, analyse their evolution over time, and ultimately reveal the underlying skill development [3].

4 The need for reflective assistance

Research laboratories and large editors have developed various tools and solutions to support skill acquisition by users. We identify three trends here. The first is the *intelligent approach*, which is supposed to offer personalized support and tips relevant to users' state and on-going activities (e.g. Clippy, the famous Microsoft Office paperclip assistant). However, in practice, such solutions often provide unexpected and inappropriate interventions, and fail to account for user's situated and high-level goals [17]. The second is the *adaptive approach*, which involves in dynamically changing user interface elements to match users' degree of expertise. Such an approach can provide short-term benefits, but it also generates confusion over long-term use as interface elements change without explicit user intervention or approval [8]. Lastly, in recent years, a third *tutoring approach* has emerged. Tutorials are created by designers or experts in order to demonstrate a particular function or technique and shared on social platforms, where novices can actively seek and control what they want to learn. Tutorial approach has gained certain success, however it remain limited to the standard features of the most popular applications, and it requires initiative from the user, as well from the experts who have to spend time creating multimedia contents [2].

These approaches only bring partial and limited solutions to the three problems related to digital skill development identified in section 2. We argue that two new classes of tools based on the visualisation of traces are especially promising here.

Reflective tools can help knowledge workers think about their practice and refine it [11]. Advanced visualizations of users' activity, such as commands usage [15], are a promising way to tackle the *integration problem* through a better understanding of software structure and the *instability problem* through better awareness of software evolution. For instance, Marie would be able to evaluate how her practice of Photoshop changed when she started to use a digitizer. She could verify the value of such a change from a visualisation showing the time passed on drawing tasks, but she would also realize that she spends more time on selection tasks. The tool could then present the trace of her old routine so she can understand why, and refine her skill.

Skill sharing tools can address the *visibility problem* by developing users awareness of other users' skills and know-how. Such tools would enable a community of users to exchange traces in order to demonstrate and exchange their best practices. For instance, if Marie discovers a novel technique related to the mask feature in Photoshop, she could share the related trace on a social platform, and discover other *masking techniques* developed by the community. Skill sharing tools based on traces would foster skill development by enabling users to explore new ways of operating a tool [15], to discuss their practices, and to be recognized as experts. In regard to the similar *tutorial approach* [2], a trace-based solution would enable to augment the videos with extra information and make sharing accessible to a wider population.

5 Conclusion and future work

In this position paper we began by briefly studying the difficulties that have been brought up by the digital revolution regarding skill development. We then underlined the shortcomings of current theoretical and empirical approaches, and we advocated the needs both for interdisciplinary theory to conceptualize digital skill development, and for longitudinal, large-scale and trace-based methods to observe such phenomenon. We finally insisted on the need to assist users in developing their digital skills, highlighting how traces of interaction could be leveraged within reflective and skill-sharing tools. We intend to address these topics in our next projects, working on the theoretical, empirical and practical (assistive) sides of digital skill development.

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